ABSTRACT #

URINARY STONE SEGMENTATION USING DEEP LEARNING NEURAL NETWORK WITH ANNOTATED CT SCANS

Murillo Freitas Bouzon[1], , Dr. Paulo Sergio Silva Rodrigues[1],
Dr. Oscar Eduardo Hidetoshi Fugita[2]
[1] Centro Universitário FEI
[2] Hospital Universitário USP

Introduction: Usually, stones in the urinary system are diagnosed through imaging tests, with computed tomography (CT) being the gold standard due to its high sensitivity and specificity. During the analysis of the exams, the specialist tries to detect stones in the CT, estimating their location and size once they find them. This procedure can be slower according to the doctor responsible and the number of exams, delaying the treatment of the patients and risking their health care. To help the diagnosis, automatic segmentation of stones in CT exams is a valuable tool that may help locate the stones and estimate their sizes faster. Deep Learning Neural Networks demonstrated promising results in the automatic segmentation of medical images. However, these Deep Learning algorithms need large datasets of images labeled for training the learning model. The lack of datasets with information on the position of the stones increases the challenge, making it difficult to train deep-learning models that need a gold standard to learn how to segment stones correctly.

Methods: In this work, we investigated the performance of a Deep Learning Neural Network for urinary stone segmentation trained with annotated CT scans containing the regions of the urinary stones manually labeled. For this purpose, we manually annotated 838 CT images, marking the stone regions for each image. Then, we trained a U-Net for urinary stone segmentation using the annotated CT images and evaluated its performance.

Results: The model segmented the stone regions correctly in most cases. Our best model obtained a Dice value of 95.1% and a Jaccard value of 91.9%. To generalize the error on unseen data, we performed a 5-fold test validation, and the model obtained a mean Dice value of $92.1 \pm 2.11\%$ and a mean Jaccard value of $86.43 \pm 1.81\%$.

Conclusion: These results indicate that using an annotated dataset for training Deep Learning models for urinary stones segmentation is a promising technique that can lead to the development of novel automatic diagnosis systems that aid the whole treatment process of urinary stones disease, helping the diagnosis, the localization, and their size estimation. In the future, this approach could be a valuable tool for developing an automated surgery system that plans the surgery path based on the characteristics extracted from the segmentation of the stone.
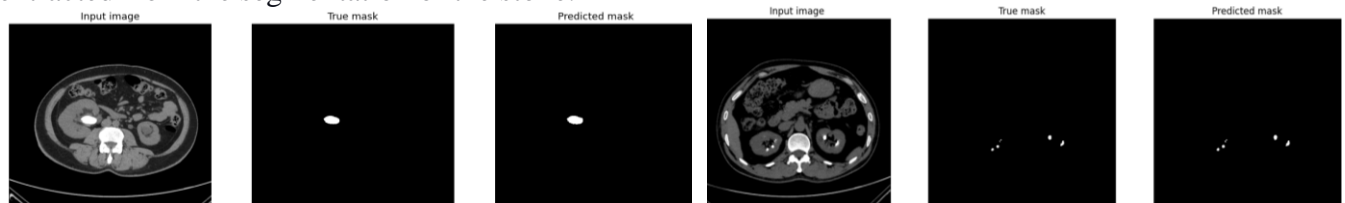
Figure: Results of the segmentation by our model
Left: Segmentation result of a single urinary stone. Right: Segmentation result of multiple urinary stones